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Clinical Microbiology and Infection 25 (2019) 249.e1–249.e6

Contents lists available at ScienceDirect

Clinical Microbiology and Infection

journal homepage: www.clinicalmicrobiologyandinfection.com

Original article

Epidemiology of respiratory pathogen carriage in the homeless population within two shelters in Marseille, France, 2015–2017: cross sectional 1-day surveys

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ARTICLE INFO

Article history:
Received 28 December 2017
Received in revised form
16 April 2018
Accepted 25 April 2018
Available online 17 May 2018

Editor: M. Paul

Keywords:
Homeless
Quantitative polymerase chain reaction
Quantitative reverse transcription–polymerase chain reaction
Respiratory pathogen carriage
Respiratory symptoms and signs

ABSTRACT

Objectives: To assess risk factors for respiratory tract infection symptoms and signs in sheltered homeless people in Marseille during the winter season, including pathogen carriage.
Methods: Data on 479 male participants within two shelters who completed questionnaires and a total of 950 nasal and pharyngeal samples were collected during the winters of 2015–2017. Respiratory pathogen carriage including seven viruses and four bacteria was assessed by quantitative PCR.
Results: The homeless population was characterized by a majority of individuals of North African origin (300/479, 62.6%) with a relatively high prevalence of chronic homelessness (175/465, 37.6%). We found a high prevalence of respiratory symptoms and signs (168/476, 35.3%), a very high prevalence of bacterial carriage (313/477, 65.6%), especially *Haemophilus influenzae* (280/477, 58.7%), and a lower prevalence of virus carriage (51/473, 10.8%) with human rhinovirus being the most frequent (25/473, 5.3%). Differences were observed between the microbial communities of the nose and throat. Duration of homelessness (odds ratio (OR) 1.77, p 0.017), chronic respiratory diseases (OR 5.27, p <0.0001) and visiting countries of origin for migrants (OR 1.68, p 0.035) were identified as independent risk factors for respiratory symptoms and signs. A strong association between virus (OR 2.40, p 0.012) or *Streptococcus pneumoniae* (OR 2.32, p 0.014) carriage and respiratory symptoms and signs was also found.
Conclusions: These findings allowed identification of the individuals at higher risk for contracting respiratory tract infections to better target preventive measures aimed at limiting the transmission of these diseases in this setting. **T.D.A. Ly, Clin Microbiol Infect 2019;25:249.e1–249.e6**

Introduction

Given their lack of customary and regular access to a conventional dwelling or residence, homeless people reside in the street and/or in shelters. The challenges of poor environmental conditions, poor physical state, smoking habit, alcohol abuse or illicit drug consumption significantly impair their health status. Behind the frequent association with mental disease and unintentional injuries, homeless people are also predisposed to infectious diseases, especially respiratory infections such as tuberculosis and pneumonia [1]. A high prevalence of chronic respiratory diseases was recorded in the homeless, including bronchitis, asthma and chronic obstructive pulmonary disease [2]. Respiratory diseases are frequently associated with death among homeless individuals [3]. Pulmonary tuberculosis is frequent in the homeless population and has been extensively studied [4,5].

In Marseille, there are an estimated 1500 homeless individuals, including more than 800 sleeping in the street and approximately 600 living temporarily at the two main shelters of the city [6]. Infectious diseases are frequent among Marseille's sheltered homeless people, including lice and *Bartonella quintana* infection, hepatitis E and C, *Tropheryma whipplei* infection, skin infections and respiratory tract infections [7]. A 50% rate of respiratory symptoms

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https://doi.org/10.1016/j.cmi.2018.04.032
1198-743X/

Table 1
Risk factors for respiratory disease: univariate analysis

Characteristics	Total (*n*)	At least one respiratory symptom or sign *n* (%)	No respiratory symptom and no sign *n* (%)	Univariate analysis Odds ratio (95% CI), p-value
Total		168 (35.3)	308 (64.3)	
Year of study[a]				
2015	125 (26.1)	37 (29.6)	88 (70.4)	
2016	156 (32.6)	74 (47.4)	82 (52.6)	
2017	198 (41.3)	57 (29.2)	138 (70.8)	
Shelter				
A	311 (64.9)	107 (35.2)	201 (65.3)	0.93 (0.63–1.38), p 0.73
B	168 (35.1)	61 (36.3)	107 (63.7)	Ref
Age				
Mean age (SD)	43.6 ± 16 years	NA		
Age range	18–84 years	NA		
≤50 years of age	318 (66.8)	98 (30.8)	220 (69.2)	Ref
>50 years of age	158 (33.2)	69 (44.2)	87 (55.8)	1.78 (1.20–2.64), p 0.004
Birthplace				
France (mainland)	71 (14.8)	39 (54.9)	32 (45.1)	Ref
France (overseas territories)	1 (0.2)	0 (0)	1 (100)	NA
North Africa	300 (62.6)	100 (33.4)	199 (66.6)	0.41 (0.25–0.70), p 0.001
Sub-Saharan Africa	43 (9.0)	7 (16.3)	36 (83.7)	0.16 (0.63–0.41), p <0.0001
East Europe	35 (7.3)	13 (39.4)	20 (60.6)	0.53 (0.23–1.24), p 0.14
West Europe	9 (1.9)	2 (22.2)	7 (77.8)	0.23 (0.04–1.21), p 0.08
Asia	20 (4.2)	7 (35.0)	13 (65.0)	0.44 (0.16–1.24), p 0.12
Other	0 (0)			NA
Mean duration of residence in France (SD)	9.88 (0–25.4)	NA	NA	
Range of duration of residence in France	0–65 years	NA	NA	
≥1 year	220 (55.3)	79 (35.9)	141 (64.1)	1.52 (0.99–2.32), p 0.06
<1 year	178 (44.7)	48 (27.0)	130 (73.0)	Ref
Visit to country of origin since immigration	126 (31.9)	51 (40.5)	75 (59.5)	1.76 (1.13–2.74), p 0.012
No visits to country of origin since immigration	269 (68.1)	75 (27.9)	194 (72.1)	Ref
Mean duration of homelessness (SD)	2.66 years (0–7.8)	NA	NA	
Range of duration of homelessness	0–52 years			
≥1 year	175 (37.6)	80 (45.7)	95 (70.6)	2.02 (1.37–2.99), p <0.0001
<1 year	290 (62.4)	85 (29.4)	204 (70.6)	Ref
Addiction				
Alcohol				
Frequent	52 (10.9)	24 (47.1)	27 (52.9)	1.75 (0.98–3.14), p 0.06
Rare or never	424 (89.1)	143 (33.7)	281 (66.3)	Ref
Tobacco				
Yes	293 (61.2)	113 (38.7)	179 (61.3)	1.48 (1.00–2.20), p 0.05
Never	185 (38.7)	55 (30.3)	129 (70.1)	Ref
Cannabis	75 (15.7)	28 (37.3)	47 (62.7)	1.11 (0.67–1.85), p 0.69
Injected substances	2 (0.4)	0 (0)	2 (100)	
Snorted substances	13 (2.7)	4 (30.8)	9 (66.2)	
Drug substitutes	1 (0.2)	1 (100)	0 (0)	
Chronic diseases				
Chronic respiratory diseases	38 (8.1)	27 (71.0)	11 (28.9)	5.12 (2.47–10.62), p <0.0001
Diabetes mellitus	36 (7.6)	14 (38.9)	22 (61.1)	1.18 (0.59–2.37), p 0.65
Cancer	5 (1.1)	1 (20)	4 (80)	
Hepatitis	10 (2.1)	8 (80)	2 (20)	
Body mass index (kg/m^2)				
Mean body mass index	24.4 ± 4.0	NA	NA	
Range of Body mass index				
Normal weight	251 (55.9)	86 (34.3)	165 (65.7)	Ref
Underweight	17 (3.8)	9 (52.9)	8 (47.1)	0.46 (0.17–0.24), p 0.12
Overweight	138 (30.7)	47 (34.1)	91 (65.9)	1.00 (0.65–1.56), p 0.97
Obesity	43 (9.6)	12 (27.9)	31 (72.1)	1.35 (0.65–2.75), p 0.41
Seasonal vaccination against influenza	71 (15.1)	31 (43.7)	40 (56.3)	1.50 (0.90–2.5), p 0.12
Respiratory carriage				
Haemophilus influenzae	280 (59.6)	90 (32.4)	189 (67.7)	0.73 (0.50–1.08), p 0.11
Streptococcus pneumoniae	59 (12.4)	32 (54.2)	27 (45.8)	2.45 (1.42–4.29), p 0.001
Staphylococcus aureus	35 (7.3)	10 (26.8)	25 (71.4)	0.72 (0.33–1.53), p 0.4
Klebsiella pneumoniae	35 (7.3)	11 (31.4)	24 (68.6)	0.83 (0.40–1.75), p 0.63
At least one virus	51 (10.8)	26 (51)	25 (49)	2.09 (1.17–3.49), p 0.012
Human rhinovirus	25 (5.3)	11 (44)	14 (56)	1.48 (0.65–3.34), p 0.34
Human coronavirus	10 (2.1)	5 (50)	5 (50)	
Influenza A virus	7 (1.5)	4 (57.1)	3 (42.9)	
Influenza B virus	7 (1.5)	5 (71.4)	2 (28.6)	
Human respiratory syncytial virus	3 (0.6)	1 (33.3)	2 (66.6)	
Human para-influenza virus	1 (0.2)	1 (100)	0	
Human metapneumovirus	0	0	0	
Co-infection				
H. influenzae + *S. pneumoniae*	43 (9.0)	24 (55.8)	19 (44.2)	2.55 (1.35–4.82), p 0.003
H. influenzae + virus	33 (7.0)	14 (42.2)	19 (57.6)	1.4 (0.68–2.85), p 0.36

Table 1 (*continued*)

Characteristics	Total (*n*)	At least one respiratory symptom or sign *n* (%)	No respiratory symptom and no sign *n* (%)	Univariate analysis Odds ratio (95% CI), p-value
H. influenzae + *K. pneumoniae*	25 (5.2)	6 (24)	19 (76)	0.57 (0.22–1.45), p 0.23
H. influenzae + *Staph. aureus*	24 (5.0)	8 (33.3)	16 (66.7)	0.92 (0.38–2.19), p 0.85
S. pneumoniae + virus	12 (2.5)	9 (75)	3 (25)	
S. pneumoniae + *Staph. aureus*	9 (1.9)	4 (44.4)	5 (55.6)	
S. pneumoniae + *K. pneumoniae*	5 (1.0)	3 (60)	2 (40)	
Staph. aureus + *K. pneumoniae*	4 (0.8)	0	4 (100)	
Staph. aureus + virus	4 (0.8)	3 (75)	1 (25)	

Abbreviations: SD, standard deviation; NA, not applicable, Ref, Reference category.
[a] Year of study was not included in the analysis, given that no intervention could be done based on this criterion.

and signs was observed in this population in winter 2005 [8]. About 8.7% carried at least one respiratory virus, with rhinovirus being the most frequent when sampled during the winters of 2010 and 2011 [9]. These preliminary findings demonstrated that respiratory infections might be frequent among sheltered homeless people in Marseille, warranting further investigation.

We described socio-demographic characteristics, underlying chronic medical conditions and addictions, clinical respiratory symptoms and signs, and prevalence of respiratory viruses and bacteria (other than *Mycobacterium tuberculosis*) in the homeless population in two shelters of Marseille over the 2015–2017 period and investigated potential risk factors.

The main objective of the study was the assessment of risk factors for respiratory tract infection symptoms and signs in sheltered homeless people during the French winter season, including pathogen carriage. We hypothesize that carriage of viral pathogens may be associated with clinical signs and symptoms as it is admitted that the vast majority of respiratory infections in adults are caused by rhinoviruses, coronaviruses and influenza viruses [10]; whereas carriage of bacterial pathogens may not necessarily be associated with clinical signs and symptoms because bacterial microorganisms that are potential aetiological agents of respiratory tract infections are also part of the resident microbiome [11]. The secondary objective was to investigate the possible association between virus–bacterium co-carriage or dual bacterial infections and respiratory symptoms and signs, as the pathogenic role of respiratory viruses in virus–bacterium co-infected individuals remains unclear [12] and because interspecies interactions are suspected in individuals infected with several respiratory bacteria [13].

Materials and methods

Study population and data collection

Ethical approvals were obtained from the Institutional Review Board and Ethics Committee of Marseille (2010-A01406-33). Cross sectional 1-day surveys were organized on 17 February 2015, 7–10 March 2016 and 6–8 February 2017 in two shelters (A and B) in Marseille, France, housing 600 homeless persons, for the night only, with a high turnover. Shelter A has a special (day–night) unit with a 35-bed capacity, dedicated to high-risk sedentary homeless people who are characterized by a high level of poverty, poor hygiene, alcoholism and mental illness. Adult homeless people were recruited on a voluntary basis. A medical doctor administered a standardized questionnaire addressing demographics, chronic medical conditions, chronic respiratory disease status (defined as suffering from one of the following conditions: asthma, chronic obstructive pulmonary disease, occupational lung diseases, or pulmonary hypertension), substance abuse, vaccination status, symptoms and signs (cough, expectoration, rhinorrhoea, dyspnoea, sore throat, sibilants, rhonchi, crackles, headache, myalgia, conjunctivitis, fever) at enrolment and physically examined the participants.

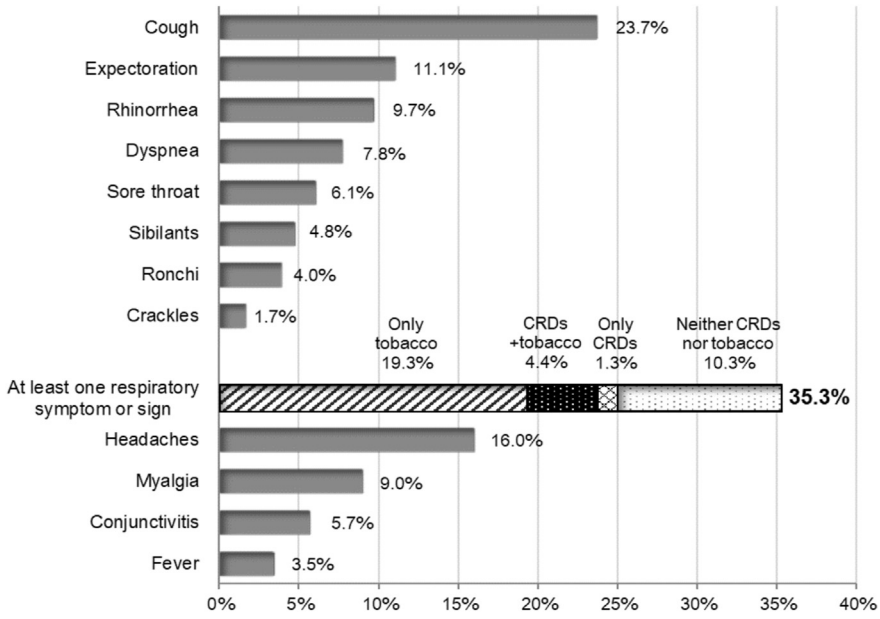

Fig. 1. Prevalence of clinical signs and symptoms over the 2015–2017 period ($n = 479$ individuals). Abbreviations: CRDs, chronic respiratory diseases.

Table 2
Prevalence (%) of bacteria and viruses detected by quantitative PCR

Respiratory pathogen	Positive carriage			
	Nasal specimen, *n* (%)	Pharyngeal specimen, *n* (%)	p-value	Nasal or pharyngeal, *n* (%)
Total	476 (100)[a]	474 (100)[a]		477 (100)[a]
Bacteria	105 (22.1)	280 (59.1)	<0.0001	313 (65.6)
Haemophilus influenzae	46 (9.8)	266 (56.4)	<0.0001	280 (58.7)
Klebsiella pneumoniae	17 (3.5)	20 (4.2)	0.61	35 (7.3)
Staphylococcus aureus	28 (5.9)	12 (2.5)	<0.001	35 (7.3)
Streptococcus pneumoniae	33 (7.0)	36 (7.6)	0.69	59 (12.4)
Virus	34 (7.1)	24 (5.1)	0.18	51 (10.8)
Influenza A virus	4 (0.8)	4 (1.0)	–	7 (1.5)
Influenza B virus	4 (0.8)	6 (1.3)	–	7 (1.5)
Human rhinovirus	20 (4.3)	7 (1.5)	<0.001	25 (5.3)
Human respiratory syncytial virus	1 (0.2)	2 (0.4)	–	3 (0.6)
Human metapneumovirus	0 (0)	0 (0)	–	0 (0)
Human coronavirus	5 (1.1)	5 (1.1)	0.99	10 (2.1)
HCoV-HKU1	0 (0)	1 (0.2)	–	1 (0.2)
HCoV-E229	3 (0.6)	1 (0.2)	–	4 (0.8)
HCoV-NL63	1 (0.2)	0 (0)	–	1 (0.2)
HCoV-OC43	1 (0.2)	3 (0.6)	–	4 (0.8)
Human para-influenza virus	0 (0)	1 (0.2)	–	1 (0.2)

[a] A total of 473 participants had both nasal and pharyngeal sampling; three participants had only nasal swabs and one had only pharyngeal swabs. Participants having at least one nasal or pharyngeal positive sample were considered positive cases.

All participants signed an informed consent. The homeless people screened were offered treatment or further evaluation based on the symptom assessment, as quantitative PCR data were obtained long after the surveys were performed.

Respiratory specimens

Nasal and pharyngeal swabs were collected from each participant, transferred to Sigma-Virocult® medium and stored at −80°C. The DNA and RNA extractions were concurrently performed using the EZ1 Advanced XL (Qiagen, Hilden, German) with the Virus Mini Kit v2.0 (Qiagen) according to the manufacturer's recommendation. All quantitative real-time PCR were performed using a C1000 Touch™ Thermal Cycle (Bio-Rad, Hercules, CA, USA). Negative control (PCR mix + sterilized water) and positive control (DNA from bacterial strain or RNA from viral strain) were included in each run. Positive results of bacteria or virus amplification were defined as those with a cycle threshold (CT) value ≤35. Individuals with at least one nasal or pharyngeal positive sample were considered positive cases.

Table 3
Risk factors for respiratory disease: multivariate analysis

Characteristics[a]	Multivariate analysis
	Odds ratio (95% CI), p-value
Age ≥50 years versus others	–
Birthplace	–
Range of duration of residence in France ≥1 year versus others	–
Visit to country of origin since immigration	1.68 (1.04–2.71), p 0.035
Range of duration of homelessness ≥1 year versus others	1.77 (1.11–2.83), p 0.017
Alcohol	–
Tobacco	–
Chronic respiratory diseases	5.27 (2.24–12.41), p <0.0001
Seasonal vaccination against influenza	–
Respiratory pathogen	
Haemophilus influenzae	–
Streptococcus pneumoniae	2.32 (1.18–5.3), p 0.014
At least one virus	2.40 (1.21–4.74), p 0.012
H. influenzae+ *S. pneumoniae* co-infection	–

[a] Only variables with p values <0.2 in the univariate analysis and with a paired correlation coefficient <0.7 were included in the multivariate analysis.

Identification of respiratory bacteria

Real-time PCR amplifications were carried out using a LightCycler® 480 Probes Master kit (Roche Diagnostics, Meylan, France) according to the manufacturer's recommendations. The *SHD* gene of *Haemophilus influenzae*, *phoE* gene of *Klebsiella pneumoniae*, *NucA* gene of *Staphylococcus aureus* and *lytA* gene of *Streptococcus pneumoniae* were detected with internal controls T4 phage as previously described [14,15].

Identification of respiratory viruses

One-step duplex quantitative RT-PCR amplifications by HCoV/HPIV-R Gene Kit (REF: 71-045, Biomérieux, Marcy l'Étoile, France) were used for the detection of human coronavirus (HCoV) and human para-influenzavirus (HPIV), according to the manufacturer's recommendations. One-step simplex real-time quantitative RT-PCR amplifications were performed by using Multiplex RNA Virus Master Kit (Roche Diagnostics, France) for influenza A, influenza B, human rhinovirus, human metapneumovirus, human respiratory syncytial virus and internal controls MS2 phage [14]. HCoV-positive samples were further screened for HCoV-HKU1, HCoV-NL63, HCoV-229E and HCoV-OC43 [16].

Statistical analysis

Statistical analysis was conducted using STATA software (version 11.1). Differences in the proportions (percentages and odds ratio (OR) with 95% CI estimations) were tested by Pearson's chi-square or Fisher's exact tests when appropriate. Two-tailed tests were used for comparisons. Univariate analysis was used to examine unadjusted associations between multiple factors (demographic, chronic medical condition), respiratory symptoms or physical finding and prevalence of respiratory pathogen carriages. A p value <0.05 was considered statistically significant. Only the variables with a prevalence ≥5.0% were considered for statistical analysis. Variables with p values <0.2 from the univariate analysis were included in the multivariate analysis. Analysis of multicollinearity among the independent variables was performed using the φ coefficient to test for correlation among binary variables; and for pairs of variables that were highly correlated (absolute value of

Table 4
Association between respiratory pathogen carriage and clinical findings in univariate analysis according to respiratory symptoms and signs

Respiratory pathogen	Odds ratio (95% CI), p-value				
	Cough	Expectoration	Rhinorrhoea	Dyspnoea	Sore throat
Streptococcus pneumoniae	2.5 (1.41–4.41), p 0.001	1.3 (0.59–2.95), p 0.51	1.03 (0.3–3.59) p 0.965	1.10 (0.41–2.95) p 0.85	1.13 (0.38–3.37), p 0.83
At least one virus	2.5 (1.37–4.58), p 0.002	2.15 (1.01–4.60) p 0.044	2.5 (1.00–6.12), p 0.047	1.68 (0.66–4.24), p 0.27	7.3 (3.26–16.42), p <0.0001

correlation coefficient >0.7), only one variable was entered into the multivariate model. Multivariable logistic regression (created by stepwise regression) was used to determine factors associated with respiratory symptoms and signs. Log likelihood Ratio Tests were performed to determine this multivariable modelling.

Results

Only two women were identified, so they were excluded. Of the 479 men who answered the questionnaire and signed consent forms, 477 agreed to undergo nasal or pharyngeal sampling. About 11 550 quantitative PCR were performed.

Characteristics and clinical status of the homeless participants

The socio-demographic characteristics, substance abuse, chronic disease and clinical features of participants are shown in Table 1 and Fig. 1. The population was characterized by middle-aged males (43.6 ± 16 years) of North African origin, with a relatively high proportion of chronic homelessness (>1 year) reported by 37.2% of individuals and with a 61.2% prevalence of tobacco smoking. About 8% reported suffering from chronic respiratory diseases. The prevalence rate of at least one respiratory symptom or sign was of 35.3% with cough, rhinorrhoea and dyspnoea as the most frequent symptoms. Most symptomatic individuals (70.8%, 119 out of 168) were smoking tobacco or suffering from chronic respiratory diseases.

Prevalence of respiratory pathogens by real-time PCR

We recorded a high prevalence of respiratory carriage of bacteria (65.6%, 313 of 477), notably, the proportion of individuals colonized by *H. influenzae* in nasal and/or pharyngeal swabs was 58.7% ($n = 280$) and that of *S. pneumoniae* was of 12.4% ($n = 59$). Fifty-one individuals (10.8%) also tested positive for at least one virus by quantitative RT-PCR. When comparing nasal and pharyngeal sampling sites, we found that *H. influenzae* was significantly more frequently detected in pharyngeal samples compared with nasal samples, whereas the prevalence of *Staphylococcus aureus* and human rhinovirus in nasal samples was significantly higher than in pharyngeal samples (Table 2). Co-infections were frequently observed with the most frequent being *H. influenzae*–virus and *H. influenzae*–*S. pneumoniae* co-infections (Table 1).

Association between demographics, chronic medical conditions, respiratory pathogen carriage and clinical findings according to respiratory symptoms and signs in univariate analysis and multivariate analysis.

Respiratory symptom and signs prevalence significantly increased with the duration of homelessness (Table 1). The prevalence of symptoms and signs was higher in individuals ≥50 years of age, suffering from chronic respiratory diseases and in individuals born in France but was lower in individuals born in Sub-Saharan Africa. Among migrants, the symptom and sign prevalence was significantly higher in those visiting their country of origin compared with others. Individuals carrying at least one virus, *S. pneumoniae* or *H. influenzae*–*S. pneumoniae* co-infection were more likely to present with at least one respiratory symptom or sign. In the multivariate analysis, only individuals experiencing chronic homelessness (OR 1.77, 95% CI 1.11–2.83, p 0.017), those visiting their country of origin (OR 1.68, 95% CI 1.04–2.71, p 0.035), those suffering from chronic respiratory diseases (OR 5.27, 95% CI 2.24–12.41, p <0.0001), and those carrying at least one virus (OR 2.40, 95% CI 1.21–4.74, p 0.012) or *S. pneumoniae* (OR 2.32, 95% CI 1.18–5.3, p 0.014) remained associated with an increased prevalence of respiratory symptoms and signs (Table 3). Overall, individuals carrying at least one virus were more likely to present with cough, expectoration, rhinorrhoea and sore throat. Carriage of *S. pneumoniae* was associated with cough (Table 4).

Discussion

The sheltered homeless population in our study was characterized by a high proportion of migrants of North African origin with a high prevalence of smoking habits and chronic respiratory diseases. We observed a high prevalence of respiratory symptoms and signs (35%) in line with the results of a survey conducted in Italy and the Netherlands [17,18]. Dry or productive cough, rhinorrhoea and dyspnoea were the symptoms most frequently observed, suggesting that both upper and lower tract respiratory infections affect a significant proportion of sheltered homeless people during winter. We found relatively low rates of influenza virus infections. Cross sectional surveys took place when influenza was epidemic in the region of Marseille. Influenza vaccination rate in the homeless population screened in our surveys was in the same range as in Marseille's overall population [19,20]. This result may indicate that the social isolation of homeless people might have a protective impact against community influenza virus transmission. One of the most important findings of this study is the very high prevalence of bacterial colonization by respiratory bacteria with *H. influenzae* (59%) and *S. pneumoniae* (13%) being the most frequent. A high prevalence of *H. influenzae* carriage (70%) was also observed by direct PCR in healthy infants from the western region of Gambia [21] and a rate of 40.9% was reported among children aged ≤6 years in day-care centres in eastern France [22]. In surveys conducted among healthy adults in the Australian Aboriginal population, the prevalence of non-typeable *H. influenzae* reached approximately 22.9% when culturing nasopharyngeal samples [23]. A 2.3% *H. influenzae* nasal prevalence was observed in Marseille's individuals originating from North Africa using quantitative PCR in 2013 [17]; however, the survey was conducted in October, which may account for a lower prevalence, as shown in another healthy Italian children population [24]. *Klebsiella pneumoniae* nasopharyngeal carriage rates have been reported to range from 3% to 15%, which is in agreement with our results [25]. This bacterium is known to be frequently multidrug-resistant [25] and further studies on drug resistance in bacteria isolated from homeless people would be of interest.

We identified chronic homelessness, chronic respiratory diseases and visiting their countries of origin for migrants as independent risk factors for respiratory symptoms and signs. We found a strong association between virus or *S. pneumoniae* carriage and respiratory symptoms and signs, reinforcing the need to increase vaccination rates in this population.

Additionally, data obtained in this study emphasize the difference between the microbial communities of the nose and throat, indicating the need for both nasal and pharyngeal swab sampling in future studies to better assess upper respiratory microbiological carriage.

Our study has several limitations. The first is that we did not use a control group for evaluation of background carriage in the healthy adult population. The second limitation is that our survey took place in winter, so we could not have an overview about seasonal variations of carriage in the homeless, whereas it was demonstrated to have impacted the airway microbial community in adults and children [24,26]. Future studies will be conducted at least twice a year (in winter and in summer). The questionnaire design did not allow a clear distinction between acute (short-term) and chronic (going on) respiratory symptoms, which needs to be considered in further studies. Finally, the level of precariousness of the homeless was limited to the duration of homelessness and more detailed information should be recorded in future studies.

In summary, we confirm the high prevalence of respiratory symptoms and signs in sheltered homeless people associated with a high level of bacterial carriage in the respiratory tract. Several risk factors for respiratory symptoms and signs were identified, allowing a better identification of individuals at higher risk on whom to base targeted preventive interventions, including notably vaccination against influenza and *S. pneumoniae* infections. Such an approach has proven effective in identifying individuals at higher risk for body lice in the same population [27] and the results of our study will benefit homeless people in the future.

Transparency declaration

The authors have reported that there are no conflicts of interest.

Funding

This work was supported by the French Government under the *Investissements d'avenir* (Investments for the Future) programme managed by the Agence Nationale de la Recherche (ANR, fr: National Agency for Research), (Reference: Méditerranée Infection 10-IAHU-03).

Acknowledgements

We thank our co-workers at the University Hospital Institute (IHU) who assisted us in recruiting, interviewing and examining participants and collecting samples, as well as Youssoupha Touré for his support in statistical analysis, Annick Abeille, Céline Gazin for excellent technical assistance and Pr. Rémi Charrel for his support in typing HCoV.

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